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QUARTERLY UPDATE

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HEAT PIPE TECHNOLOGY
A BIBLIOGRAPHY WITH ABSTRACTS

QUARTERLY UPDATE
SEPTEMBER 30, 1972

ASSEMBLED BY
THE HEAT PIPE INFORMATION OFFICE
of

THE TECHNOLOGY APPLICATION CENTER
INSTITUTE FOR SOCIAL RESEARCH & DEVELOPMENT
THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO

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PREFACE

Heat Pipe Technology is a continuing bibliographic summary of research on the subject of the heat pipe. The first volume was published in the spring of 1971 and is cumulative through March of that year. A 1971 Annual Supplement has been published and distributed. Additional copies are available from the Technology Application Center.

This update to Heat Pipe Technology cites the additional references identified during July, August, and September of 1972. It is the third in a 1972 quarterly series intended to provide "current awareness" to heat pipe researchers.

A library containing essentially all of the articles and publications referenced in this update, the cumulative volume, and in the 1971 Annual Supplement has been established. Although a considerable effort has been made to insure that the bibliography is complete, readers are encouraged to bring any omissions to the attention of this office.

The Technology Application Center is one of six regional dissemination centers established by NASA's Technology Utilization Program to evaluate and disseminate new technology to the general public and commercial business.

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A. GENERAL INFORMATION, REVIEWS, SURVEYS

No citations in update, September 30, 1972

B. HEAT PIPE APPLICATIONS

B. 1 GENERAL APPLICATIONS

72046 PRODUCTION OF I-123 PATENT APPLICATION

James W. Blue, inventor (to National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio).
Filed 25 April 1972. 9 p. (NASA-Case-LEW-11390-1; U.S. - Patent-Appl-SN-247434) Avail: TAC

A device for the production of high purity radioiodine for thyroid measurements and other medical applications is described. A cesium heat pipe is bombarded with high energy particles which cause a spallation reaction. The products of the reaction are a xenon isotope (Xe-123) and contaminants. The contaminants are removed in a dry ice cold trap. The Xe-123 condenses in a liquid nitrogen trap and is allowed to decay to radioiodine (I-123).

72047 DEVELOPMENT OF A PLANAR HEAT PIPE FOR COOLING LARGE CAPACITY BATTERIES

E.T. Mahefkey, Jr. (Air Force Aero Propulsion Lab, Wright-Patterson AFB, Ohio), Dec. 71. AFAPL-TR-71-39. 94 p. Avail: TAC.

A planar (rectangular cross section) heat pipe was fabricated and tested using electrical heaters to simulate battery waste heat. The device was constructed of 0.025 in. stainless steel, with two layers of 100-mesh stainless steel screen as a capillary wick; water was used as the working fluid. Transient and steady state response was investigated. External axial temperature profiles were measured for 5, 12, and 20 watts applied power, internal evaporator and condenser temperatures were also measured. Operation of the device was stable and repeatable within a temperature range of 50 to 180°F; no temperature or pressure fluctuations were noted.

72048 PRELIMINARY STUDY OF THE NUCLEAR SUBTERRENE

E.S. Robinson, R.M. Potter, B.B. McInteer, J.C. Rowley, D.E. Armstrong, R.L. Mills (Los Alamos Scientific Lab., New Mexico) April 1971. Contract W-7405-eng-36. 62 p. Avail: TAC

The rock-melting drill was invented at Los Alamos Scientific Laboratory in 1960. Electrically heated, laboratory-scale drills were subsequently shown to penetrate igneous

rocks at usefully high rates, with moderate power consumptions. The development of compact nuclear reactors and of heat pipes now makes possible the extension of this technology to much larger melting penetrators, potentially capable of producing holes up to several m in dia and several tens of km long or deep. Development of a rapid, versatile, economical method of boring large, long shafts and tunnels offers solutions to many of man's most urgent ecological, scientific, raw-materials, and energy-supply problems. A melting method appears to be the most promising and flexible means of producing such holes. It is relatively insensitive to the composition, hardness, structure, and temperature of the rock, and offers the possibilities of producing self-supporting, glass-lined holes in almost any formation and (using a technique called lithofracturing) of eliminating the debris-removal problem by forcing molten rock into cracks created in the bore wall. Large rock-melting penetrators, called Electric Subterrenes or Nuclear Subterrenes according to the energy source used, are discussed together with problems anticipated in their development. It is concluded that this development is within the grasp of present technology.

72049 PASSIVE HEAT RECOVERY AS AN ENERGY CONSERVATION MEASURE
Benjamin T. Rogers (Consulting Engineer, Embudo, New Mexico).
From Building Systems Design, Feb. 72, p. 27-30 and March 72,
p. 11-14. Avail: TAC

This paper presents the practical ideas for conserving energy and natural resources by using the heat pipe. The term "passive" is used to describe a device that utilizes no external energy to perform its function. The heat pipe is introduced as a passive energy recovery device in several environmental control situations.

72050 HEAT PIPE OVEN FOR HOMOGENEOUS MIXTURES OF SATURATED
AND UNSATURATED VAPORS. APPLICATION OF NaLi
C. R. Vidal, M.M. Hessell (National Bureau of Standards,
Boulder, Colorado). Journal of Applied Physics, 1972,
43(6), 2776-9 (Eng). Avail: TAC

A heat pipe oven was developed to produce homogeneous mixtures of a saturated vapor with an unsaturated vapor at any arbitrary well-defined ratio. The oven is able to handle materials of widely different vapor pressures and the zone containing the homogeneous vapor mixture can extend over any desired path length. With this heat pipe oven containing Na and Li, the laser- and collision-induced fluorescence spectrum of the NaLi molecule was used to study the operation of the oven. The 1st observation of a propensity rule for a polar molecule (the $\Delta J = +1$ collision-induced NaLi line is stronger than the corresponding $\Delta J = -1$ or 0 line) is reported.

B. 2 THERMIONIC AND THERMOELECTRIC CONVERTERS

72051 DESIGN AND OPTIMIZATION OF A FAST HEAT PIPE THERMIONIC REACTOR, 1

H. Hanke (Scientific Translation Service, Santa Barbara, California. Translation into English from Atomkernenergie (Munich). V. 18, 1971, p. 61-69). Feb. 1972. Contract NASW-2035, 31 p., refs. Avail: TAC

The concept of an energy supply plant for space vehicles, consisting of a fast reactor as heat source and out-of-core thermionic converters heated and cooled by heat pipes, is designed and optimized. The criterion for optimization is the cost-to-power ratio. The costs are given by the price of the fissionable material and the expense for transport of the device into orbit. The reactor power is limited by the maximum tolerable values for the temperature at the free surface of a cell and for the output current of a single converter.

72052 DEVELOPMENT OF A HIGH VOLTAGE HEAT PIPE THERMIONIC MODULE. FINAL TECHNICAL REPORT, OCTOBER 1, 1969—JUNE 30, 1971

R.W. Longsdorff (RCA Corp., Lancaster, Pennsylvania, Industrial Tub Division). July 1971. Contract At-(30-1)-4161. 62 p. Avail: TAC

Research directed toward the design, fabrication, and testing of a 5V 10 diode heat pipe thermionic module is reported. It was found that the development of the internally series connected module concept appears to be a basis for obtaining an output voltage of approximately 28 volts in advanced modules. While the concept was not proven through the actual operation of the working model, development of the key module components, such as the integral emitter/collector tri-layer assembly and arc suppression coating, has shown the feasibility of the concept. The development of a lithium heat pipe for distribution of the input thermal power has also been shown. The concept design should be modified to gain further thermal stress relief in the collector-to-collector interconnection ring joint to permit E-B welding without risking the integrity of the arc suppression coating. The design might also be modified to permit a stepped approach of emitter to heat pipe assembly in order to eliminate the risk of molybdenum-to-molybdenum seizure during assembly.

B. 3 AEROSPACE ORIENTED APPLICATIONS

72053 COOLING SYSTEMS FOR SATELLITE SENSORS

K. Kögler, J. Lorschiedter (Dornier System GmbH, Friedrichshafen, West Germany). In: Space activity in the field of ecology and earth resources; International Convention on Space, 12th, Rome, Italy. March 23-25, 1972, Proceedings. (A72-31226 15-13) Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1972, p. 243, 245-251. Avail: TAC

Survey of the various cooling methods available for application to satellite sensors, and comparison of their respective merits. The methods considered include cooling systems with cryogenic heat pipes, cryogenic sublimation cooling, high-performance radiation cones, and surface treatment of components.

B. 4 NUCLEAR SYSTEMS

72054 ISOTOPE KILOWATT PROGRAM QUARTERLY PROGRESS REPORT FOR PERIOD ENDING DECEMBER 30, 1971

A.P. Fraas, G. Samuels (Oak Ridge National Lab., Tennessee) Contract W-7405-eng-26. Apr. 1972, 32 p. Avail: TAC

Activities in programs to develop 2-, 3-, and 5 kW(e) radio-isotope energy conversion systems are reported. In October four capsules were removed from the capsule decomposition test block after 7085 h of operation at 600°F. Test results indicate that a 5-yr unattended life should be attainable for a proposed full-scale organic Rankine cycle system. The organic capsule decomposition test continued throughout the balance of the quarter without incident. The total operating time on the original capsules at the end of December was 8477 h and the time on the new capsules was 1392 h. Fabrication of components for the quarter-scale organic fluid decomposition test loop was completed and assembly of the components for the loop was about 60% completed by the end of December. The thermoelectric module continued to operate throughout the quarter to give 3156 h at the end of December. Some evidences of degradation in the electrical output have begun to appear. The design analysis and the design of the heat pipes for the full-scale heat block-shield test have been completed. Results of design analysis of these new heat pipes with a simpler construction indicate that, ideally, they should give sufficient output for all inclinations from normal vertical to an inclination of -19° (i.e., with the condenser below the evaporator region). The components for the first heat pipe for the shield block test

have been fabricated, and preliminary test results are favorable. Recent experience at Los Alamos with stainless steel-sodium heat pipes indicates that both cold trapping and hot trapping are required to make the performance of the heat pipe approach calculated values. The thermal conductivity tests on the first combined aluminum screen-foil insulation were completed. Insertion of the foil in the screen matrix gave a marked improvement in the thermal radiation losses and thus the overall insulating value. The meltdown test of the combined aluminum screen-foil insulation specimen was then conducted. Results of a preliminary analysis of the data and inspection of the screen following the meltdown indicate that the insulation will protect the fuel elements in the event that normal heat removal from the block is lost. This type of insulation was then chosen for the $\frac{1}{4}$ -scale thermal insulation test rig, and the system built. The system was placed in operation December 26 and thermal conductivity tests with a system nitrogen pressure of 15 psia were initiated. The heat block-shield unit was received and set up for testing. A simulated fuel loading test was run by bringing the simulated fuel elements to temperature and then inserting them into the holes in the heat block-shield. No difficulties were encountered during the insertion of the seven elements. The shipping and long-term storage tests were completed for both SrTiO_3 and SrF_2 fuel with maximum temperatures in the simulated fuel capsules of 1042 and 979°F respectively. In a test simulating an accident in which the unit fell from a truck it was found that, with the unit laying on its side and 110° of the surface covered with sand, the maximum fuel element temperature was 1161°F. Detail design work on the full-scale organic system continued. About 60% of this work was completed at the end of December. A comprehensive analysis of the control system has been initiated.

B. 5 ELECTRONIC APPLICATIONS

72055 A 400 AMPERE HIGH POWER TRANSCALENT SEMICONDUCTOR
THYRISTOR DEVICE, SUPPLEMENTARY REPORT NO. 2, REPORT
NO. 4, 1 JANUARY - 31 AUGUST 1971

S.W. Kessler (Radio Corporation of America, Lancaster,
Pennsylvania). September 1971. Contract DAAK02-69-C-0609.
44 p., refs. Avail: TAC

Work performed was devoted to the development of a silicon thyristor wafer which could be cooled from both sides in the transcalent package to take maximum advantage of the thermal dissipation capabilities of the heat pipe.

C. HEAT PIPE THEORY

C. 1 GENERAL THEORY

No citations in update, September 30, 1972.

C. 2 HEAT TRANSFER

72056 FEEDBACK CONTROL OF VARIABLE CONDUCTANCE HEAT PIPES
Walter B. Bienert (Dynatherm Corporation under contract to Ames Research Center). 1 page Tech Brief. Avail: TAC

The performance of variable conductance heat pipes used to regulate the temperature of a heat source can be improved by introduction of a feedback loop. One uses a passive feedback system and the other uses an active feedback system to implement such a loop.

72057 MATHEMATICAL MODELING OF HIGH AND LOW TEMPERATURE
HEAT PIPES - FINAL REPORT

S.W. Chi (George Washington University, Washington, D.C., School of Engineering and Applied Science). Grant NGR-09-010-070, Dec. 1971, 94 p., refs. Avail: TAC

Mathematical models are developed for calculating heat-transfer limitations of high-temperature heat pipes and heat-transfer limitations and temperature gradient of low temperature heat pipes. Calculated results are compared with the available experimental data from various sources to increase confidence in the present math models. Complete listings of two computer programs for high- and low-temperature heat pipes respectively are appended. These programs enable the performance of heat pipes with wrapped-screen, rectangular-groove or screen-covered rectangular-groove wick to be predicted.

72058 VAPORIZATION HEAT TRANSFER IN CAPILLARY WICK STRUCTURES
J.K. Ferrell, Jack Alleavitch (North Carolina State University, Raleigh). Chemical Engineering Progress Symposium Series, 66: No. 102, 82-91 (1970). Avail: TAC

The mechanisms of vaporization heat transfer from wick-covered heated surfaces were studied. It was found that for values of the heat flux below the critical, the mechanism of vaporization heat transfer from wick covered surfaces is one of conduction across a thin, liquid saturated film in contact with the heated surface, which is maintained by the capillary forces existing at a liquid-vapor interface within the wick. The liquid-vapor interface appeared to be located at the minimum pore diameter in the first layer of particles on the

surface and resulted in a nearly constant heat transfer coefficient. This makes the concept of a heat transfer coefficient much more useful than in ordinary pool boiling. A maximum operable heat flux (critical heat flux) was reached when the capillary forces were no longer sufficient to maintain a liquid saturated film at the heated surface. For wick materials which are in contact with the heated surface, and whose properties can be characterized by known values of porosity, capillary rise, and permeability, both the heat transfer coefficient and the critical heat flux can be predicted by methods outlined.

72059 THE NONSTATIONARY TEMPERATURE FIELDS OF THE WALL OF A PIPE AND THE HEAT CARRIER FOR SMALL VALUES OF THE BI CRITERION

B.M. Galitseiskii, G. A. Dreitser. Trans. of Izvestiya Vysshikh Uchebnykh Zavedenii Aviatsionnaya Tekhnika (USSR) n2 p. 90-98, 1970, by Susskind (Army Foreign Science and Technology Center, Charlottesville, Virginia). Rept. no FSTC-HT-23-15-72. 27 September 71, 16 p. Avail: TAC

The authors discuss the nonstationary heat exchange process in a pipe in the case when the heat transfer coefficient of the heat carrier is known.

C. 3 CONDENSATION AND EVAPORATION

72060 RESTARTABLE HEAT PIPE

Arnold P. Shlosinger (TRW Systems Group, TRW, Inc. under contract to Ames Research Center). 1 page Tech Brief, Avail: TAC

A heat pipe, which includes a second, low freezing point fluid in addition to its normal working fluid, can readily start operating after it has been cooled to or below the freezing point of its working fluid. Methyl alcohol is introduced as a freezing point depressant.

C. 4 FLUID FLOW

No citations in update, September 30, 1972

D. DESIGN AND FABRICATION

D. 1 GENERAL

72061 THEORY AND DESIGN OF VARIABLE CONDUCTANCE HEAT PIPES
B.D. Marcus (TRW Systems Group, Redondo Beach, California).
Contract NAS2-5503. April 1972, 248 p., refs. Avail: TAC

A comprehensive review and analysis of all aspects of heat pipe technology pertinent to the design of self-controlled, variable conductance devices for spacecraft thermal control is presented. Subjects considered include hydrostatics, hydrodynamics, heat transfer into and out of the pipe, fluid selection, materials compatibility and variable conductance control techniques. The report includes a selected bibliography of pertinent literature, analytical formulations of various models and theories describing variable conductance heat pipe behavior, and the results of numerous experiments on the steady state and transient performance of gas controlled variable conductance heat pipes. Also included is a discussion of VCHP design techniques.

72062 THIRTY KILOWATT HEAT PIPE DEVELOPMENT
RCA Corp Lancaster Pa Industrial Tube Division. Final
technical rept. 15 April 70 - 30 June 1971. Contract DAAB07-
70-C-0217. 30 June 1971, 81 p. Avail: TAC

A program was conducted for the development, fabrication and test of a heat pipe radiator for cooling a 30 kilowatt microwave klystron. A design concept was generated which employs twelve heat pipes in radial array to extract heat from the klystron collector. Detailed calculations were performed for the design of the individual heat pipes and the heat pipe to air heat exchanger. A one sixth size model was constructed and tested to evaluate the engineering design.

D. 2 WICKS

72063 A STUDY OF OPTIMUM WICK DESIGN IN WATER HEAT PIPES
ANNUAL REPORT

K.T. Feldman, Jr. (University of New Mexico, Albuquerque, Bureau of Engineering Research). Contract N0014-68-A-0155. Rept. No. ME-54 (72) ONR-012. Feb. 72, 27 p. Avail: TAC

Analytical study of evaporation from grooves; experimental study of evaporation from grooves; AND study of evaporation from screens.

D. 3 MATERIALS

72064 FABRICATION AND EVALUATION OF ALUMINUM HEAT PIPES
Dynatherm Corporation, Cockeysville, Maryland. Technical
Summary Report. Contract NAS5-11271. July 1970. 42 p.,
refs. Avail: TAC

An evaluation is presented for the current heat pipe system on the OAO spacecraft, in order to increase its capability for future missions. A detailed analysis was made of the requirements, and approaches for the design of optimized heat pipes to meet future needs were identified. A composite wick heat pipe was developed, which has significantly higher transport capability than those of conventional wick design.

72065 DEVELOPMENT OF A 600° CENTIGRADE HEAT PIPE ASSEMBLY.
SUPPLEMENT TO FINAL TECHNICAL REPORT
RCA Corp., Lancaster, Pennsylvania. 30 Oct. 1971. Contract
AT(29-2)-2683, 43 p. Avail: TAC

A nickel heat pipe concept using potassium as the working fluid was developed for use with radioisotope heat sources. An important feature of the concept is a reservoir section pressurized with argon, which is located above the condenser and acts to contract the condensing region of the pipe as the power level of the heat source decays. The methods for and results from life testing three of these heat pipes to 6,000, 10,000, and 41,000 hours are described.

E. TESTING AND OPERATION

72066 THERMAL TEST PLAN FOR LARGE VARIABLE CONDUCTANCE HEAT PIPE

F. Edelstein (Grumman Aerospace Corporation, Bethpage, New York). Contract NAS8-27793. 24 Nov. 1971, 15 p. Avail: TAC

The procedure to be followed in determining the thermal performance of a variable conductance heat pipe is documented. The nominal one-inch-diameter aluminum pipe is of a cold reservoir type whose overall length is nine feet. It has a capacity of 2 to 4 kW's equivalent to 8 to 16 kW-ft and an overall temperature control range of 50 to 95F. Initial tests will be conducted with the pipe charged with ammonia to determine its capacity limits. Following introduction of the non-condensable gas (nitrogen), the variable conductance features of the pipe will be used.

72067 HEAT PIPE: NEW HIGH-TEMPERATURE HEAT TRANSFER DEVICE V.B. Eliseev, D.I. Sergeev (Joint Publications Research Service, Washington, D.C. Trans. of mono. Chto Takoe Teplovaya Truba, Moscow, 1971, 134 p.). 11 April 1972, 112 p. Avail: TAC

The authors present the principles of the operation of smooth-walled and capillary heat pipes, their design, testing methods, and current fields of application.

72068 TUBE IDENTIFIER: A PHYSICAL DESCRIPTION OF TUBES TESTED IN THE OSW PROGRAM ON IMPROVED HEAT TRANSFER SYSTEM FOR EVAPORATORS: ADVANCED LTV HEAT TRANSFER SURFACES

H.W. Hoffman, L.G. Alexander (Oak Ridge National Lab., Tennessee). Oct. 1971. Contract W-7405-eng-26. 36 p., revised. Avail: TAC

A physical description is given of the evaporator-condenser tubes examined at the Oak Ridge National Laboratory under the program on advanced LTV heat transfer surfaces.

72069 TECHNIQUES ASSOCIATED WITH THERMAL-VACUUM TESTING OF THE OAO-C HEAT PIPES

James P. Marshburn (National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland). In its "Space Simulation, 1972, p. 933-946," refs. Avail: TAC

The mechanical problems associated with testing the

two high heat load pipes are discussed. One of these pipes was tested three times before being accepted. The first test resulted in the discovery of non-condensable hydrogen gas, which prevented the pipe from functioning properly. The second test was a repeat of the first, to see if all the gas had been removed. The third test was to see if any changes had occurred to the pipe as a result of saddle modifications. Saddle modifications were necessary because the epoxy binding agent between the saddles and the pipe had decomposed during the testing. The test problems discussed deal with the specially designed heat-removal devices, the mobile tilt table, the table position indicator, and the heat input mechanisms, all of which were necessary to conduct a high-heat load, thermal-vacuum test. The final results showed that the techniques used were adequate for thermal-vacuum testing of heat pipes.

72070 PERFORMANCE OF A SODIUM HEAT PIPE

T.I. Sweeney (Battelle-Northwest, Richland, Washington). Chemical Engineering Progress Symposium Series, 66: No. 102, 72-81 (1970). Avail: TAC

The operational characteristics of a sodium heat pipe having a wick structure consisting of wire wrapped rods was investigated. Although better flow characteristics are potentially possible with such a wick, the dry out limit was below the expected dry out limit based on current theories. Possible reasons for this difference are discussed. A large temperature gradient, accompanied by oscillations in temperature and heat removal rates, was observed when the cooling coils were very short. (Although this is similar to the description of heat pipe start-up problems reported by other investigators, non-condensables, which were present, could be causing the decreased performance.) Premature dry out was observed when large increases in power were taken, but wick recovery was also shown. A thermocouple, placed in vapor space between evaporator and condenser, was found to be a very sensitive dry out indicator.

72071 HEAT AND MASS TRANSFER IN LOW-TEMPERATURE HEAT PIPES

L.L. Vasilev, L.P. Grakovich, S.V. Konev (Akademiia Nauk Belorusskoi SSR, Institut Teplo-i Massoobmena, Minsk, Belorussian SSR). Inzhenerno-Fizicheskii Zhurnal, Vol. 22, May 1972, p. 806-810. In Russian. 5 refs. Avail: TAC

A stainless-steel 1800mm long, 19mm in diameter heat pipe using freon-22 and freon-11 as the working fluid is studied experimentally. The influence of the tilt angle of the heat pipe and the coolant temperature in the condenser on the heat transfer characteristics of the heat pipe is determined. The influence of the boundary conditions on the heat and mass transfer is studied.

72072 THE OPERATION OF ROTATING NON-CAPILLARY HEAT PIPES
John Sanford Woodard (Naval Postgraduate School Monterey, California). Master's Thesis. March 72, 62 p. Avail: TAC

A Nusselt-type analysis was performed for laminar film condensation on the inside of a truncated rotating cone, which included the interfacial shear between the vapor and condensate, the vapor pressure drop, the thermal resistance in the condenser wall, and the condenser exterior cooling mechanism. An approximation of this analysis made it possible to find a numerical solution for small half cone angles greater than zero. A parametric study was performed of this approximate solution for various fluids, RPMs, half cone angles, and exterior heat transfer coefficients. A non-capillary rotating heat pipe containing distilled water as the working fluid was tested. It was rotated at 700, 1400, 2100, and 2800 RPM, and heat transfer rates of the heat pipe were determined experimentally for different vapor saturation temperatures corresponding to electrical power inputs ranging from 1 Kw to 7 Kw.

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- 00001 LEFFERT C B
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U.S. PATENT 3670495
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- 00002 FREGGENS R A
METHOD OF MAKING A HEAT PIPE HAVING AN
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U.S. PATENT 3672020
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- 00003 BIENERT W B LEVEDAHL W J
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THERMAL CONTROL AND POWER FLATTENING FOR RADIOISOTOPIC
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- 00004 KIRKPATRICK M E
FLUID HEAT TRANSFER METHOD AND APPARATUS
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U.S. PATENT 3673306
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ANNULAR HEAT PIPE
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- 00006 MOORE J D JR
HEAT LINK, A HEAT TRANSFER DEVICE
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U.S. PATENT 3677336
JULY 18, 1972
- 00007 NOREN D W
METHOD OF FORMING A HEAT PIPE
U.S. PATENT 3680189
AUGUST 1, 1972
- 00008 JOHNSTON F C KRAUSE W A
BUS BAR ELECTRIC POWER DISTRIBUTION SYSTEM WITH
HEAT PIPE HEAT DISSIPATING MEANS
U.S. PATENT 3681509
AUGUST 1, 1972

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00009 ARCELLA F G BRUMM R E
HEAT PIPE WICK FABRICATION
U.S. PATENT 3681843
AUGUST 8, 1972

00010 ABU-ROMIA M M
ELECTROKINETIC HEAT PIPE
U.S. PATENT 3682239
AUGUST 8, 1972

00011 LEFFERT C B
HEAT PIPE ELECTROGASDYNAMIC CONVERTER
U.S. PATENT 3683214
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00012 GROVER G M COYLE E L
HEATING SYSTEM FOR A RAILWAY TANK CAR OR THE LIKE
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00013 CHI J W H FLAHERTY R
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00014 STURM C H WEBER W
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U.S. PATENT 3688838
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00001	U.S. PATENT 3670495#
00002	U.S. PATENT 3672020#
00003	U.S. PATENT 3672443#
00004	U.S. PATENT 3673306#
00005	U.S. PATENT 3677329#
00006	U.S. PATENT 3677336#
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